Change of Physiological and Psychological Functions Based on the Combination of Early and Late Experience

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Developmental psychology is categorized into normative descriptive and experimental-predictive psychology (Thompson and Grusec, 1970). As for the pioneer for normative-descriptive developmental consideration, we can retrieve Rousseau (1762), Freud (1917), Senden (1932) and Montessori (1838). In "Emile" it is written "education of human beings begins at the point of birth ... Experience goes ahead of the discipline". Freud (1917) denoted that evil experience of childhood functions traumatic as one of the reason of neurosis. Montessori (1938) agreed with such psychoanalytic point of view and denoted the child as a "mental embryo". She also insisted that the period from five months after birth until the age of three is considered as a "*sensitive period*". Therefore, she performed a sensory education. Senden (1932) published critical reports concerning deficits of visual perception, occurring even after operations to cure congenital cataract.

As for the experimental-predictive research, Hebb (1947) was the first to publish a thesis making use of the key word "*early experience*". To verify a causal relationship, full-scale physiological and psychological experiments on animals were started. In 1946, new animal intelligence test using many detour problems was developed by Hebb and Williams (1946).

As the word "early experience" suggests, sensory experiences in our early period of life has a more profound effect than the same experiences occurring at any other period. This fact, is described as the "*critical period hypothesis*". The researchers who agree with such concept are Lorenz (1935), Hebb (1949), Scott (1958), Levine (1962), Hubel & Wiesel (1970) and Dennis (1973).

On the other hand, other researchers insist that there is no critical period in development (Eysenck, 1960; Denenberg, 1962; Schneirla & Rosenbalt, 1963, Rosenzweig, *et al.*, 1968, Renner & Rosenzweig (1987). It is well known that Eysenck criticized Freud's psychoanalytic point of view confirming that neurosis occurs at any time irrespective of childhood experience. Therefore, he created behavioral therapy. Rosenzweig (1968) and Bennett (1976) found that brain weight increases more through rearing in an "enriched condition (EC)", namely an enriched environment in early life than through rearing in the "impoverished condition (IC)", namely an impoverished environment. However, basing on the EC-IC percentage differences, Bennett (1976) showed that there was an increase in brain weight in an enriched condition, even if the differential rearing of rats was started in a relatively late stage, such as from 185 or 290 days after birth (Rosenzweig, *et al.*, 1968; Bennett, 1976).

Our theoretical hypotheses concerning critical period are as follows.

—First of all, we suppose the importance of the independent variable related to the timing of the experience which is confined not only to the early experience (EE), but also to the late experience (LE).

—Secondly, conjunction of EE and LE is

important. This means that, to experience firstly EC as EE and even continue to experience EC as LE is most effective for the physiological and psychological development of the organism. On the other hand, initial lack of EC in EE and the continuity of lack in EC even in LE is most dangerous because it has much more impact.

Thirdly, if the same amount and the same period of EC are given, EE is more effective than LE.

Such a combined point of view of EE and LE (Mitani, 1962, 1977a, b, 1989) has its origin in Rousseau (1762). In "Emile", he wrote there are two important periods in life. The first is childhood, and the second is adolescence and marrige. He also suggested the causal relationship of these two periods. Freud (1917) considered three independent variable that can produce neurosis, namely sexual predispositions, childhood experiences and later occuring experiences or traumatic experiences. He denoted also the interaction of these three factors in a conceptual figure (Freud, 1917. p. 555). Scott *et al* (1974) hypothesized four critical periods in human development.

Experiment I

To ascertain our three theoretical hypotheses about change of physiological and psychological function based on the combination of EE and LE, 2 × 2 factorial design, as shown in Table 1, was performed using 45 rats. Factor A is "Early EC", namely whether EC is given as EE or not. Factor B is "Late EC", namely whether EC is given as LE or not.

Method

1 Subjects

Forty five Wistar male rats, born on September 24th 1991, in the psychological laboratory of Okayama University were used.

2 Apparatus

Fifty days after birth, the animals were divided into two groups, namely EC and IC, and housed in metal cages of 650 × 450 × 250 mm. Solid food and water were given ad liberatum in the corner. The cages provided for enriched condition (EC) contained a tunnel, swing, and black equilateral triangle with 14.758 mm for each side on white plastic of 250 × 450 mm (Mitani, 1989). For impoverished condition (IC), in order to induce sensory restriction and to reduce clear visual patterns experience, the cages were completely covered by white plastic. It lacked a tunnel, swing and the triangle.

O.F.T: Denenberg-Morton (1962) Type Open Field Test: It composed of twenty five black 200 × 200 mm sections 1,000 × 1,000 × 450 mm divided by white lines. During the experiment the laboratory room was illuminated by 2 light bulbs of 40 Watts, lit up at a distance of two meters.

E.R.T: Elevated Runway Test: A total length of 1,465 mm was used. The runway itself was 850 mm long. The size of the starting box was 200 × 100 mm. The goal box measured 300 × 200 mm. In a completely dark experimental room, a 10 Watt bulb hung over the goal box, lighting up this goal from a distance of

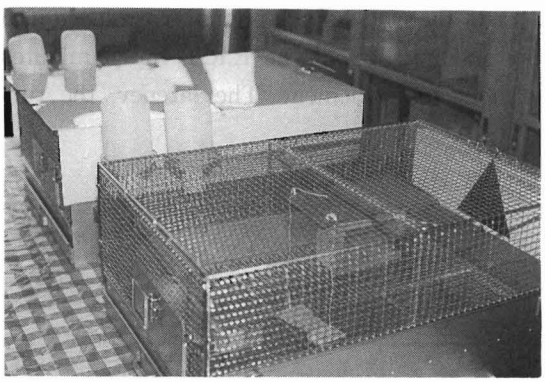

Photo 1 Enriched condition (EC) and impoverished condition (IC).

precisely 400 mm. Latency and performance or crossing time was recorded from the border line, which is 100 mm from the starting point.

3 Differential Rearing

Fifty days after birth in which they were under the same conditions, the forty five rats were divided into EC ($N=22$) and IC ($N=23$), being matched with respect to the mean and standard deviation of their weights and spent 92 days as EE.

From 142 days after birth, animals were divided into four groups. Twelve rats from EC were changed to IC and eleven from IC to EC. After this combination, we obtained four groups: EC-EC ($N=11$), EC-IC ($N=12$), IC-EC ($N=11$), IC-IC ($N=11$) and spent 92 days as LE. The temperature of the laboratory was set at 23 ± 3 °C and humidity was kept at 57 %.

4 Procedure Design

a) Weight: Animal body weight was measured 50, 142 and 234 days after birth.

b) O.F.T: Each animal was put into the O.F.T for a period of 3 minutes. The activity, urination and defecation were registered in order to study the change of physiological and psychological functions based on the combination of early and late experience. The activity was traced by pencil every minute. Concerning urination and defecation, we only noted how often they occurred in each minute.

c) In the E.R.T: Each animal was placed into the starting box of the E.R.T for 10 minutes without reinforcement. The latency, the running time, the urination and the defecation were registered.

Table 1 Experimental design
EC: enriched condition; IC: impoverished condition.

		[B] Late EC	
		+	−
[A] Early EC	+	EC-EC ($N=11$)	EC-IC ($N=12$)
	−	IC-EC ($N=11$)	IC-IC ($N=11$)

Result

a) Weight

Figure 1 shows the growth curve of each group. After 50 days of birth the mean weight of the 45 Wistar male rats was 189 grams. At 142 days after birth, this means after 92 days EE differential rearing, we had noted that the EC group was thinner than IC group which already showed an obese tendency. The difference between the two groups was significant ($t=2.4014$, $p<.05$, $df=21$).

b) O.F.T

—**Total activity:** Figure 2 illustrates the mean total activity in the O.F.T. It was recorded that EC-EC group obtained the highest mean with a score of 96.45 of traversed sections, while the IC -IC group obtained a lower one with a score of 57.64. The EC-IC group obtained the second place with 81.08. The mean total activity of the IC-EC group was 74.91. Table 2 shows that only "Early EC source" was significant ($F=5.24$, $p<.05$, $df=1$ and 40).

—**Days activity:** Figure 3 shows the mean days activity in O.F.T. The highest mean activity for all the groups was registered the first day of our experiment. This mean decreased

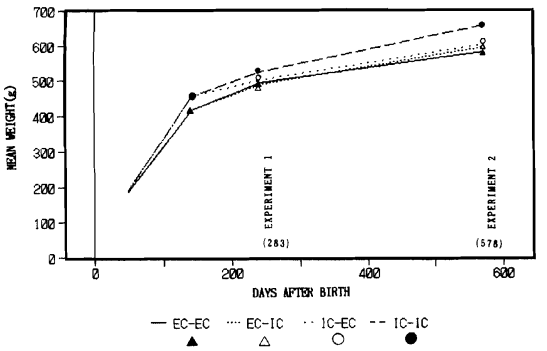

Fig. 1 Growth curve of Wistar male rats changes according to the combination of early and late experience.

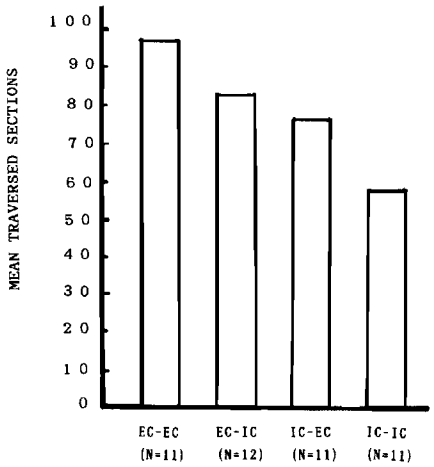

Fig. 2 Mean total activity in open field test (Experiment 1).

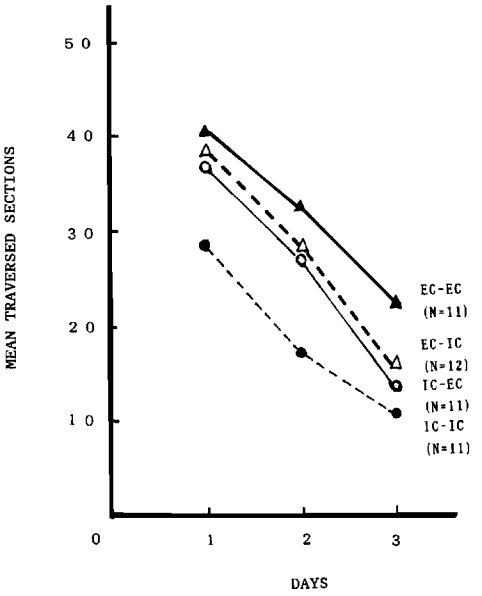

Fig. 3 Mean days activity in open field test (Experiment 1).

Table 2 Analysis of variance of total activity (3 days) in open field test (Experiment 1).

Source	SS	df	MS	F
Early EC [A]	6169.11	1	6169.11	5.24*
Late EC [B]	2520.20	1	2520.20	2.14
[AB]	108.21	1	108.21	0.09
E	47048.90	40	1176.22	

* $p<.05$

Table 3 Analysis of variance of days activity (3 days × 4 groups) in open field test (Experiment 1).

Source	SS	df	MS	F
Groups [G]	2935.32	3	978.44	3.12*
Days [D]	9556.95	2	4778.47	15.24**
[GD]	221.97	6	36.99	0.12
E	37613.80	120	313.45	

* $p<.05$, ** $p<.01$

during the second and third day for all the groups. The EC-EC group performance was the best, while the performance of the IC-IC group was the lowest one. On the first day, only the tendency was registered between EC-EC and IC -IC groups ($t=1.887$, $p<.10$, $df=20$). But, on the second day the difference between these two groups was significant ($t=2.003$, $p<.05$, $df=20$) while this was not the case on the third day. Table 3 illustrates that groups were significant $\{F(3, 120)=3.12, p<.05\}$ and days were significant $\{F(2, 120)=15.24, p<.01\}$.

—**Minutes activity:** Figure 4 shows the mean minutes activity. The first point that should be mentioned is that the activity of all the groups decreased with time. Similar to the days mean activity, the highest mean for all the groups was registered during the first minute. However, it decreased during the second minute significantly for all the groups except for the EC-EC group and continued to decline during the third minute except for the same EC-EC group. It is also important to remark that the EC-EC group obtained the highest mean activity during the first, second and third minute. Moreover, the EC-EC group was significantly more active than the IC-EC group ($t=2.386$, $p<.05$, $df=20$) and the IC-IC group ($t=2.969$, $p<.05$, $df=20$) during the third minute. On the

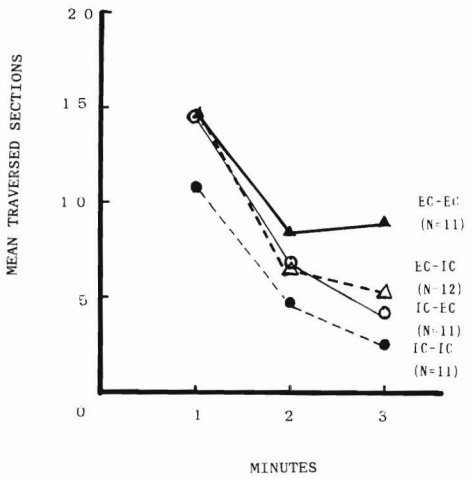

Fig. 4 Mean minutes activity in open field test (Experiment 1).

Table 4 Analysis of variance of minutes activity (3 minutes × 4 groups) in open field test (Experiment 1).

Source	SS	df	MS	F
Groups [G]	3570.59	3	1190.20	4.81**
Minutes [M]	12254,90	2	6127.43	24.76**
[GM]	1125.69	6	187.62	0.76
E	29698.60	120	247.49	

** $p<.01$

other hand, the lower mean activity was obtained by the IC-IC group whose activity decreased deeply with time.

—**Urination:** The highest mean of urination occurrence was registered for the EC-EC group while the lower one was registered for the IC-IC group. A significant group difference was found between these two groups ($t=2.40$, $df=20$, $p<.05$). We also noted a significant group difference between the EC-EC and the IC-EC groups ($t=2.21$, $df=20$, $p<.05$). Between the IC-EC and the IC-IC groups only tendency was registered.

—**Defecation:** In this case, we noted also the importance of early and late experience. We noted significant group difference between the EC-IC and the IC-IC groups ($t=2.203$, $df=21$, $p<.05$). The higher mean of total defecation occurrence observed in EC-IC group is certainly the result of the change in the environmental conditions.

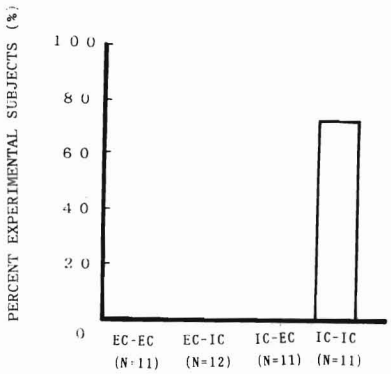

Fig. 5 Percent of animals showing hair pulling symptom (Experiment 1).

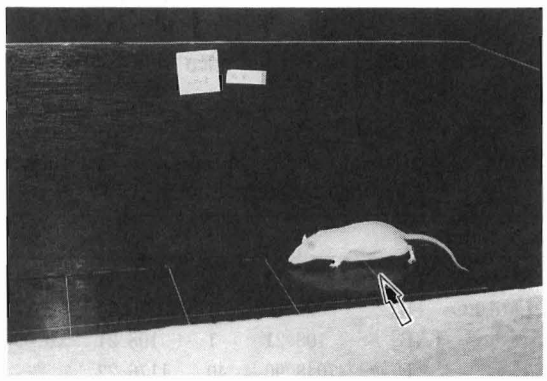

Photo 2 Hair pulling symptom which appeared in IC-IC animals.

—**Hair Pulling Symptom:** Figure 5 shows the percentage of the animal hair pulling symptom. Especially the findings concerning the observation that pronounced hair chewing occured only in IC-IC group, are interesting. In fact, 73 percent of the IC-IC animals have had this symptomatology. The actual psychological and physiological reason is not yet known to us and hence further studies are necessary.

c) E.R.T

We especially noted the negative score of the

IC-IC group. In fact only 9.1 percent of the animals started to cross the E.R.T but at the end not even one of this group had crossed. The highest means of urination and defecation occurrence were registered for the IC-IC group.

Discussion

1 Physiological change

As it became apparent from Figure 1, IC-IC Wistar rats gained the most weight and EC-EC animals were the thinnest. After 92 days of EE differential rearing, the EC group was significantly thinner than the IC animals in the case of Wistar rats. That is to say, early IC produces obesity in Wistar rats and it continues if late IC follows. These results correspond to the results of Rosenzweig, *et al.* (1962, 1968), Huck and Price (1975), Mitani (1974, 1989).

In the case of Fischer 344 rats, namely relatively smaller sized type rats, very early EC has tendency to suppress weight. However, after the sixteenth day, EC has tendency to promote growth in weight of Fischer 344. In mouse, already on 38th day, EC had significantly increased the weight.

On other hand, the results related to the urination occurrence revealed that the sensitivity and the susceptibility were more important in the EE than the LE.

The other interesting physiological change is that 73 percent of IC-IC animals had a hair pulling symptom. No animal in EC-EC, EC-IC or IC-EC groups, showed such results. The continuity of IC from EE to LE is physiologically most deteriorative for the organism. Thus, the second hypothesis is verified.

2 Psychological change

EC-EC animals revealed the highest total activity in O.F.T. IC-IC animals showed the lowest total activity. As it is apparent from Table 2, the independent variable "Early EC" function significantly increases the general activity of the organism. That is to say, EC-EC environment produced much general activity. The "Late EC" function was not significant. Thus, the third hypothesis is verified.

As it became clear from Figure 3 and Figure 4, the EC-EC animals's activity was highest every three days, and every three minutes. On the other hand, IC-IC animals activity was lowest every three days and every three minutes. The groups functions changed during the experiment, namely the EC-IC group and IC-EC group activity were in the middle of the result of EC-EC and IC-IC groups.

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初期経験と後期経験との組み合わせによる生理的機能と心理的機能の変化

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人生の比較的初期の感覚的経験ないしは学習を初期経験（EE：early experience）とよび，それ以後の経験を後期経験（LE：later experience）とよぶ。心身の発達にとって初期経験が特に重大な影響を与えるとする説を臨界期仮説（critical period hypothesis）とよぶが，それに反対する学者もある。

45匹のウイスター・ラットを生後50日に豊富な環境群（EC：enriched condition）と貧弱な環境群（IC：impoverished condition）に分けて92日間の分化的EEを与えた。両群とも650×450×250㎜の金属ケイジであるが，ECにはトンネル，ブランコ，白の小壁面に14.758㎜の黒い三角形が提示されていた。ICには以上の物体はなく，視覚的パターン視を制限するために周囲を黒いプラスチィク板で覆った。142日にそれぞれの群を折半して92日の分化的LEを与えた。すなわち，〝初期EC〟×〝後期EC〟の2×2実験計画によるEC-EC（$N=11$），EC-IC（$N=12$），IC-EC（$N=11$），IC-IC（$N=11$）の4群構成である。

EEの終了した142日の生理的機能としての体重は，初期ECの2群の平均が初期ICの2群の平均よりも5％レベルで有意に少なくスリムであった。

生理心理機能をみるために実施したオープンフィールド・テスト（OFT）の結果，1日3分間・3日間の全活動性に関して〝初期EC〟のみが有意に活動性を促進することが明らかになった。〝後期EC〟もある程度効果を持ち，活動性はEC-EC，EC-IC，IC-EC，IC-IC群の順に高くなった。日間の活動性は1％で有意に減少し，群差も5％で有意であったが，群と検査日の交互作用はなかった。第2日のEC-ECの活動性はIC-ICより5％で有意に高かった。検査時間としての分間の活動性は1％で有意に減少し，群差も1％で有意であったが，群と検査時間との交互作用はなかった。第3分のEC-ECの活動性は，IC-IC及びIC-ECより5％で有意に高かった。

ところが，OFTの排尿（urination）はその活動性と相関して出現し，EC-ECの排尿はIC-ECとIC-ICのそれぞれよりも5％で有意に多く，〝初期EC〟により感受性（susceptibility）が高められ精神的活動も豊かになることが示唆された。排便（defecation）に関してはEC-ICが最も多く，IC-ICよりも5％で有意に多かった。また142日の時点で，IC-IC　群の73％にのみ左体側に禿（hair pulling）が出現していた。

心理的探索力と勇気を見るために実施した高架式直走路（ERT）の結果，IC-ICのみが特異な反応を示した。すなわちIC-IC群の9.1％のみが出発したものの，強化のないゴールまで渡橋したラットはこの群のみ皆無であった。またこの群の排尿は多く，特に排便は著しく多い。IC-ICにより不安・恐怖が形成され，神経一筋の共応機能が著しく疎外されていくことが示唆された。

以上により，(1)生理心理的機能に及ぼす独立変数としての環境要因ないしは経験要因は，初期経験（EE）としてのみ作用するのではなく，後期経験（LE）としても作用しうること。(2)初期経験と後期経験との組み合わせまたは論理積が重要であり，そのパターンに対応して生理心理的機能が異なった展開を示すこと。(3)同量・同期間の経験が与えられる場合は，望ましい効果となる場合も望ましくない効果となる場合も，初期経験の方が後期経験よりも強い影響を及ぼすこと，という3仮説が支持された。

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